Peripheral Awareness in a Theatre of Work

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ABSTRACT
Knowledge workers typically work at a number of different places and cooperate with local or remote colleagues. At the same time they work in both the physical world with physical artefacts and in the electronic world with electronic artefacts. In all these different settings they need information about their co-workers and about shared artefact as a basis for efficient work that adequately contributes to the overall activities of the work group. In this paper we present an awareness information environment that captures information from the user's physical and electronic environment, processes this information, and makes users peripherally aware of this information.

INTRODUCTION
Knowledge workers typically work at a number of different places and cooperate with local or remote colleagues. At the same time they work in both the physical world with physical artefacts and in the electronic world with electronic artefacts. In all these different settings they need information about their co-workers and about shared artefact as a basis for efficient work that adequately contributes to the overall activities of the work group.

In face-to-face settings users can easily capture the information they need. In settings with geographically dispersed groups, electronic support for these types of information, often referred to as group awareness [4], is needed. The developers of such technological support for group awareness face several challenges. Besides pure technological challenges of how to capture, how to store and process, and how to present the information, several psychological and social problems and trade-offs have to be tackled. Disruption is a prominent example psychological and social challenges [7]. Here the trade-off lies in the fact that users want and need up-to-the-moment information about persons they are cooperating with and about artefacts they are sharing with others. At the same time, users have to perform their foreground task and do not want to be disrupted and disturbed by information that might not even be relevant for the current task.

In this paper we present an awareness information environment that captures information from the user's physical and electronic environment, processes this information, and presents the information in various different indicators. It provides a broad range of awareness indicators. Users can chooses the indicators they like and customise them to their needs.

THE THEATRE OF WORK ENABLING RELATIONSHIPS
The Theatre of Work Enabling Relationships (TOWER) environment aims to support distributed work groups or virtual communities with group awareness in their current work context. It provides an infrastructure for facilitating chance encounters and spontaneous conversations among remote users. For this purpose, the infrastructure has various sensors capturing information about users and their activities and a range of indicators notifying users about the presence, availability, and current activities and tasks of the other users.

Sensors capture information from the electronic and the physical environment of the users. Sensors in the electronic world can capture user activities within the TOWER environment (e.g., logins, logouts), user activities on Win* platforms (e.g., changes to files, sharing of folders and files, starting of applications, opening of documents), user activities in shared workspaces (e.g., a sensor for the Basic Support for Cooperative Work (BSCW) system [2] records all activities in the shared workspaces such as user logins and logouts, folder creation, invitations users to shared folders, document uploads), access to Web servers.

A broad variety of *indicators* present the awareness information. Examples are lightweight indicators such as pop-up windows with pure text or tickertapes displaying messages about the other users and shared artefacts; AwarenessMaps, which provide awareness information in the context of shared workspaces; the TowerWorld, which presents shared artefacts and users in a 3D multi-user environment; ambient interfaces, which present the information in the physical environment of the users; and mobile client presenting light-weight information for users on the road.

Subsequently we will primarily focus on the various indicators providing peripheral awareness in the users' electronic and in the physical environment; we will describe AwarenessMaps, the TowerWorld, ambient interfaces, and the mobile client.

AwarenessMaps
The AwarenessMaps have been designed to augment the BSCW system, a Web-based shared workspace system. Shared workspaces are nested repositories that can contain various kinds of information such as documents, URLs, results of Web searches, and threaded discussions. They are typically owned and managed by a group of users, who have to authenticate in order to access the contents of the workspace, change the existing content, or upload new documents. The BSCW system is mainly used for managing shared workspaces of multi-party projects (e.g.,

multi-national projects of the European Union), and for sharing documents among teachers and students [1]. BSCW workspaces and the user population can become huge. For instance, the public BSCW server currently has more than 100.000 registered users (cf. http://bscw.gmd.de). AwarenessMaps provide users with up-to-the-minute information on other members of the respective shared workspace (PeopleMap) as well as its structure and the contents (DocumentMap).

The PeopleMap shows an array of pictures of users with recent activities (cf. the area below 'Your location:' in Figure 1). The pictures are displayed in the order of the actuality of the represented user's last activity and fade out over time. That is, when a user performs an action in a workspace (e.g., reads or uploads a document) their picture is inserted on the very left of the PeopleMap in a sharp format. Pictures fade out with the increasing age of a user's actions. Typically, a linear fade-out over 24 hours is used: the pictures get increasingly transparent and the pictures of users who have not performed any action within the last 24 hours fade out completely and are not visible any more.

PeopleMaps allow some simple, yet powerful, user interaction: Users can navigate their mouse over a picture to view tool-tip like information on the name of the user and the manipulated document as well as the type and time of action. A click on a user's picture opens an additional window with detailed contact information on the respective user including a URL with the user's email address.

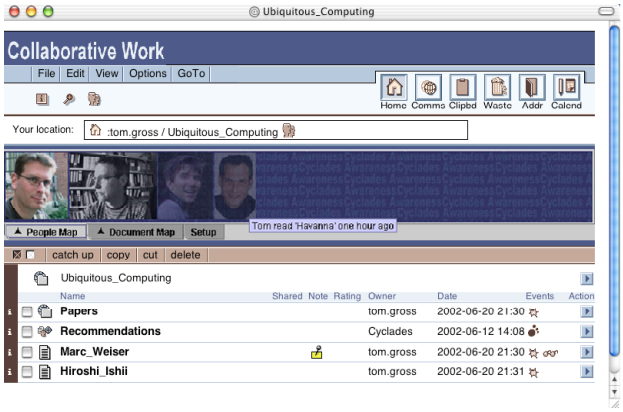

Figure 1. Shared workspace with a PeopleMap.

The DocumentMap provides a schematic overview of the nested structure of a shared workspace consisting of folders, sub-folders, and documents. The structure is mapped into an array consisting of nested rectangles. The mapping is based on space-filling algorithms for the visualization of hierarchical information structures from Johnson and Shneiderman. The algorithms are described in [8]; some Open Source implementations of treemaps are available at http://treemap.sourceforge.net/. We will not go into details here.

In our visualization each rectangle represents an individual document; the bounding rectangles represent the folders containing it. Figure 2 shows a simple example, in which a shared workspace consists of two top-level folders (where the five left-most rectangles represent documents contained in the first top-level folder; and the remaining rectangles represent documents contained in the second).

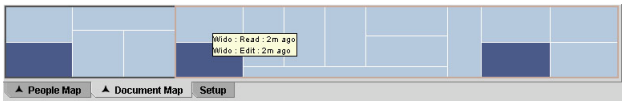

Figure 2. DocumentMap.

The layout of the DocumentMap is recalculated and redrawn, whenever the underlying structure of the shared workspace changes. Basically documents are represented in light blue color. When a document is manipulated (e.g., created, updated, read), the color of the associated rectangle changes to dark blue. Similar to the PeopleMap the color changes back to light blue after a period of 24 hours.

The TowerWorld

The TowerWorld is a 3D multi-user world; it consists of a stage that is dynamically created based on shared information space such as BSCW workspaces [2] or the content of other document management systems and avatars navigating on this stage and performing symbolic actions. Figure 3 shows screenshots of a TowerWorld: the left picture presents a view from the distance, where users can get a good overview of the whole stage with all its cubicles representing the documents; and the right picture shows a close-up of the same TowerWorld with more details (e.g., icons representing the file types, avatars positioned according to the current activities of the respective users).

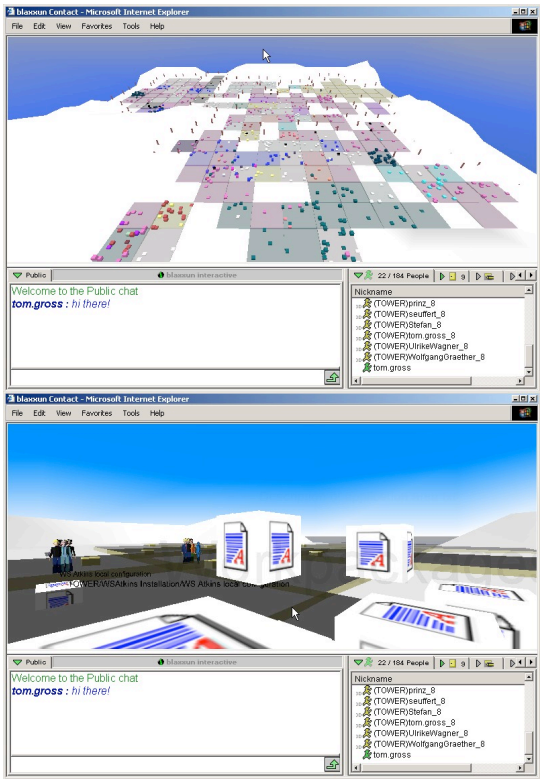

Figure 3. TowerWorld: (a) overview from a distance; (b) details in a close-up.

The stage evolves in response to the patterns of use in the shared information space. The stage is generated and adapted according to rules and semantic mappings that can be specified by the users. Various attributes of the

documents in the shared information space can be visualised such as the type of a document, the size of a document, the frequency of manipulations to a document, the creator of a document, the similarity among documents, and so forth. These attributes can be mapped to the size of the cubicles in the TowerWorld, their shape, their colour, their position, their clustering, and so forth. Another criterion for the stage creation is the granularity of the mapping of document sets into the stage. User workshops yielded different opinions whether a more detailed view or a more abstract overview provides better context for the visualisation of user activities. In the current implementation users can select between different worlds, each created by different selection criteria and rules for generation and mapping. In an overview world for example objects in the TowerWorld represent only folders of the shared information space, while the detailed TowerWorld provides a representation for each document. In the overview world activity spots are easier to recognise while in the detailed world clusters of objects with a similar semantic are easier to identified.

The stage of the TowerWorld is populated with avatars representing users and representing their current activities as symbolic actions such as automatic navigation through the TowerWorld and gestures. The emphasis in symbolic acting is to show the contextual information telling users about where the other users are, who they are and what they are doing right now. With symbolic acting the context dependent actions of all users are shown at all times so the world can seem like a more active place as well as more closely reflecting the activities of a user group. We let the system do the walking–and the acting. This is a very powerful and engaging way of solving problems in mediated communication.

Ambient Interfaces

A range of multimodal ambient interfaces and the AwareBots were built. *Multimodal interfaces* address multiple human sensory modalities and multiple channels, of the same or different modalities [3]. Some examples of multimodal ambient interfaces that were developed are a fan, a lamp, and a fish tank. The fan addresses the haptic sense of the user—it blows air into the face of the user. The desktop lamp addresses the visual sense—it points to the ceiling of an office room and illuminates the ceiling, its intensity can be changed in a subtle way. The fish tank addresses the visual and auditory sense of the user—it can release bubbles in different intensities, these bubbles can not only be seen, but also heard, if their frequency goes beyond a certain threshold.

AwareBots are ambient interfaces presenting awareness information in the shape of robots. Several AwareBots were developed with the LEGO Mindstorms Robotics Invention System [11]. LEGO offers several advantages for the participatory design of ambient interfaces: users can easily build and change their AwareBots, users can easily personalise existing AwareBots, and the AwareBots are aesthetically pleasing. For instance, the RoboDeNiro AwareBot (cf. Figure 4) can lift its hat when another user logs in; it can rotate its body when new email has arrived; and the user can press its arm in order to log into the system.

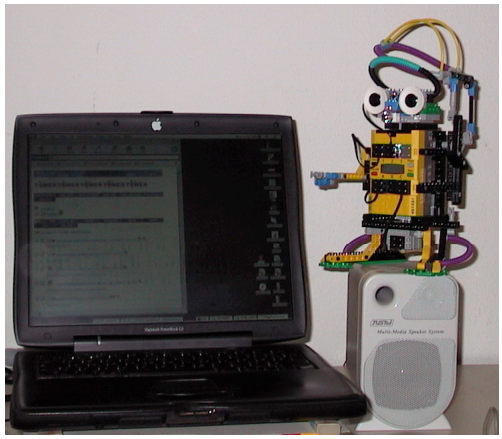

Figure 4. The RoboDeNiro AwareBot.

Details about these multimodal ambient interfaces and AwareBots as well as about others can be found in [6].

Mobile Client

The PResence AVailability and Task Awareness client (PRAVTA) is a lightweight and mobile supplement to the TowerWorld and the other indicators that are very powerful and highly personalisable, but stationary [5]. In fact, it allows users to send messages to the tickertape of the online users, to actively query various types of awareness information, to enter und update awareness information about themselves anytime and anywhere. Being based on WAP [12], the PRAVTA prototype can be accessed from any mobile device that supports WAP such as mobile phones; palmtops; and SmartPhones.

After the users have authentified they can query information about the presence of other users resulting in a table with all online users. They can check the availability of others and get a table with the current availability. Figure 5 shows a mobile phone, and the login window and result of 'Who is online?', 'Check availability', and 'Check tasks'.

For users who are in their everyday work environment the TOWER sensors can capture information about their presence, availability, activities, and so forth. As PRAVTA can be used in any surrounding, the user has the possibility to manually update their status.

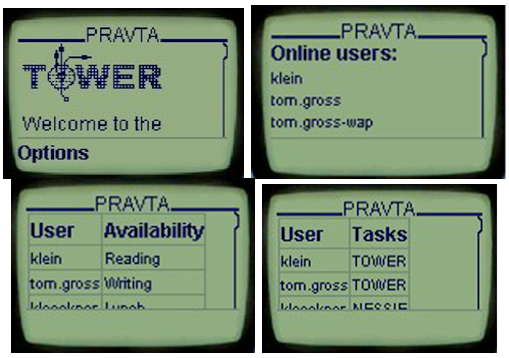

Figure 5. PRAVTA on a mobile phone: login window and the presentation of awareness information.

TOWER consists of the following components: an event and notification infrastructure, a space module that dynamically creates the 3D space according to the changes to shared documents [10], a symbolic acting module that creates and animates the avatars according to

the users' actions [9], and a docudrama module that can replay past states of the 3D multi-user environment and allows the retrieval of past scenes of the 3D multi-user environment.

CONCLUSIONS

In this paper we have presented various indicators for providing peripheral awareness to distributed group members. Due to space limitations we could not go into further details concerning its implementation or report on results of user studies we did in the context of this project in two companies.

BIOGRAPHICAL INFORMATION

Tom Gross holds a diploma and a doctorate degree in Applied Computer Science from the Johannes Kepler University Linz, Austria. He is a senior researcher in the Computer-Supported Cooperative Work research group at the Fraunhofer Institute for Applied Information Technology FIT (formerly known as GMD-FIT—German National Research Center for Information Technology). He is was a member of the European IST-project TOWER and coordinates the activities of the European IST-project CYCLADES at FIT. His research interests include computer-supported cooperative work, human-computer interaction, and global information systems. He is teaching HCI and CSCW at the Johannes Kepler University Linz, Austria, and at the Technical University of Aachen, Germany.

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